

## Occupational Risk Factors for Laryngeal Cancer on the Texas Gulf Coast

Linda Morris Brown,<sup>1</sup> Thomas J. Mason, Linda Williams Pickle, Patricia A. Stewart, Patricia A. Buffler, Keith Burau, Regina G. Ziegler, and Joseph F. Fraumeni, Jr.

*Epidemiology and Biostatistics Program, Division of Cancer Etiology, National Cancer Institute, Bethesda, Maryland 20892 [L. M. B., T. J. M., L. W. P., P. A. S., R. G. Z., J. F. F.], and the Epidemiology Research Unit, School of Public Health, University of Texas Health Science Center at Houston, Houston, Texas [P. A. B., K. B.]*

### ABSTRACT

Analyses are reported from a case-control interview study of incident laryngeal cancer on the Gulf Coast of Texas. Study subjects were 183 white men with squamous cell carcinoma of the larynx and 250 frequency matched controls. Occupational exposures were examined controlling for potential confounding by cigarette smoking and alcohol consumption. Significantly elevated risks were seen for men employed in the public services industry (transportation, communication, utilities, sanitary service; relative risk (RR), 1.6; in metal fabricating (RR, 2.1), construction (RR, 1.7), and maintenance (RR, 2.7) occupations; and for workers potentially exposed to paint (RR, 1.8) and diesel or gasoline fumes (RR, 1.5). Elevated risks of border-line significance were seen for men employed as woodworkers/furniture makers (RR, 8.1) and for those with occupational exposure to asbestos (RR, 1.5). When asbestos was categorized by intensity of exposure, a significant positive gradient was found.

### INTRODUCTION

Previous investigations of laryngeal cancer have identified a number of plausible occupational risk factors, but results have been limited by small numbers of cases (1-4) or inability to control for potential confounding by smoking, drinking, or diet (5-8). The major risk factors for laryngeal cancer are tobacco and alcohol consumption (5, 9-12), and a protective role of fruit and vegetable consumption has been suggested (13). This case-control study was conducted in an industrialized area along the Texas Gulf Coast, where elevated rates of respiratory cancer had previously been identified (14, 15), using control subjects selected from the general population and from death certificates. The study thus provided an opportunity to evaluate occupational risk factors among newly diagnosed cases of laryngeal cancer while controlling for previously reported risk factors.

### MATERIALS AND METHODS

Laryngeal cancer cases were ascertained from hospital records and tumor registries at participating (56 of a possible 67) hospitals in a 6-county area along the Gulf Coast of Texas (Brazoria, Chambers, Galveston, Harris, Jefferson, and Orange). All diagnoses of primary laryngeal cancer (ICD-9 161.X, 231.0) among white males aged 30 to 79 living in these 6 counties were selected from participating hospitals. Medical records were abstracted to determine the histological type of laryngeal cancer. Two hundred twenty living cases and 83 dead cases were identified during the period of case ascertainment, July 1, 1975, through June 30, 1980.

Controls were a stratified sample of white males without respiratory cancer resident in the 6-county area and were frequency matched to the cases by 5-yr age group, vital status, ethnicity, and county of residence (e.g., Harris or other). The controls were selected from 3 sources: 113 deceased controls from the mortality tapes of the Texas Department of Health; 215 living controls under age 65 from drivers license records;

and 56 living controls aged 65 and over from Medicare records provided by the HCFA.<sup>2</sup>

During 1980 and 1981, interviews with living patients, or with close relatives if the patients were deceased, were conducted by local interviewers under the supervision of the Epidemiology Research Unit, School of Public Health, University of Texas Health Science Center at Houston. Information was sought on lifetime history of tobacco and alcohol use, usual dietary patterns approximately 4 yr prior to interview, lifetime occupational and residential histories, and demographic characteristics.

Interviews were completed for 153 living cases (69.5%) and 56 dead cases (67.5%). The percentages of completed interviews were 62.8% for the dead controls, 60.9% for the drivers license controls, and 85.7% for the HCFA controls. The reasons for noninterviews are presented in Table 1.

The usual number of cigarettes smoked per day and the number of years smoked were obtained from the questionnaire, and an estimate of lifetime cigarette exposure (packyears) was calculated as the product of these two variables. Mean lifetime consumption of beer, wine, and hard liquor was ascertained from the questionnaire. Average weekly ethanol intake was estimated by assuming that 1 fluid oz of beer, wine, and hard liquor yields 1.1, 2.9, and 9.4 g of ethanol, respectively (16). Total ethanol consumption was calculated by summing the contribution from all three types of alcoholic beverages. This total was then converted into hard liquor equivalent drinks (in fluid ounces per week) for ease of interpretation. The dietary section of the questionnaire, used only in direct interviews, sought information about usual adult diet 4 yr prior to interview. All responses were converted to the average number of times the food item was eaten per week over a year interval. Frequencies of consumption for the food group fruits and vegetables were formed by summing the frequencies for the appropriate food items.

The name of the employer, job title, and duties were collected for each job held for 6 mo or longer. As a measure to limit the length of the interview, it was decided to collect information only on jobs held after 1939. While this allowed us to ascertain adult jobs for nearly all of the subjects and to obtain information on any exposures that might have been unique to World War II, it did restrict our ability to analyze exposures by year of first exposure, since 70% of the study subjects' first reported year of employment was in the decade 1940 to 1949.

Sixteen industrial and 24 occupational categories were formed based on the major groups in the SIC system (17) and the DOT (18). Only those categories reported by 45 or more study subjects (12 industrial and 8 occupational) are included in this report. In addition, potential high-risk occupational categories were identified by reviewing the published literature (1, 2, 5, 6, 11, 19-23). Presented are the 13 specific occupations reported by 5 or more study subjects. Finally, 12 chemical and physical agents were identified which have been previously associated with an excess risk of laryngeal cancer or as being present in industries linked to laryngeal cancer (1, 2, 6-8, 11, 19-23). One of the authors (P. A. S.), an industrial hygienist, classified job titles for potential exposure to each substance. Assessments were made based on a general review of the literature and on personal experience without knowledge of the case/control status of subjects. Summary exposure variables for ever/never exposed, number of years exposed, and year first exposed were generated for each agent per study subject.

The measure of association between variables of interest and laryngeal cancer was the RR, approximated by the odds ratio (24), with 95%

Received 7/31/87, revised 12/5/87; accepted 12/29/87.

The costs of publication of this article were defrayed in part by the payment of page charges. This article must therefore be hereby marked *advertisement* in accordance with 18 U.S.C. Section 1734 solely to indicate this fact.

<sup>1</sup> To whom requests for reprints should be addressed, at Epidemiology and Biostatistics Program, National Cancer Institute, 6130 Executive Blvd, North Building, 4th Floor, Bethesda, MD 20892.

<sup>2</sup> The abbreviations used are: HCFA, Health Care Financing Administration; SIC, Standard Industrial Classification; DOT, Dictionary of Occupational Titles; RR, relative risk; CI, confidence interval.

Table 1 Reasons for noninterviews of cases and controls by vital status

Reasons for noninterviews	Cases				Controls			
	Living		Dead		Living		Dead	
	No.	% of identified	No.	% of identified	No.	% of identified	No.	% of identified
Any reason	67	30.5	27	32.5	92	33.9	42	37.2
Respondent refusal	27	12.3	7	8.4	45	16.6	12	10.6
Unable to locate respondent	28	12.7	10	12.1	24	8.8	16	14.2
Respondent lived outside study area	9	4.1	9	10.8	23	8.5	13	11.5
Physician refusal	2	0.9	0	0	0	0	0	0
Study procedures not followed	1	0.5	1	1.2	0	0	1	0.9

CI's calculated according to the method described by Gart (25). Binary logistic models were used to calculate risks for the occupational variables of interest (26, 27). Cigarette smoking (less than 60 packyears *versus* 60 or greater) and alcoholic beverage consumption (less than 21 drinks per wk *versus* 21 or greater) were included in all models to adjust for potential confounding. Finer categorizations of the smoking and alcohol variables were not included in the logistic model because they did not substantially alter the occupational risk estimates. Other variables including vital status, age, education, county of residence, and fruit and vegetable consumption were examined and found not to be confounders of occupational risk factors. Mantel's (28) extension test (two-tailed) was used to test occupational factors for a trend in duration or amount of exposure.

## RESULTS

The final study population consisted of 183 (136 living, 47 dead) cases and 250 (179 living, 71 dead) controls after excluding 26 cases without histologically confirmed squamous cell tumors. The median age at diagnosis was 62 yr for the cases, and the median grade of school completed was 12 for both cases and controls. To assess the potential for confounding by smoking, alcohol, and diet, we examined each of these factors independently and in a logistic model with occupation. Cases were more likely than controls to have used cigarettes (RR, 4.7; CI, 2.8 to 9.9) and alcohol (RR, 2.1; CI, 0.9 to 5.3) and less likely to have eaten fruits and vegetables (RR, 0.6; CI, 0.3 to 0.8; and RR, 0.7; CI, 0.4 to 1.3 for moderate and high consumption, respectively). A detailed evaluation of risks associated with tobacco and alcohol (including their interactions) and with dietary factors will be reported separately. Since diet did not affect the occupational risk estimates, it was not included with smoking and drinking in the logistic analysis.

Relative risks were calculated for the 12 industrial and 8 occupational categories with at least 45 subjects ever employed (Table 2). Although petroleum and chemical manufacturing and shipbuilding were hypothesized to be high-risk industries, the adjusted RRs for men ever employed in these industries were unremarkable (RR, 0.9 and 1.0, respectively). Significantly elevated risks were seen for the industry category of transportation, communication, utilities, or sanitary services (RR, 1.6), which is hereafter referred to as "public services," and for the occupations of construction (RR, 1.7) and metal fabricating (RR, 2.1).

In the public services industry, the risk was most prominent among men employed in water transportation (20 cases, 9 controls), particularly marine cargo handling. The risks for men employed in public services did not vary substantially by duration of employment. Construction occupations (DOT Code 86) included the following job titles: carpenters; brick and stone masons and tile setters; plumbers, gas fitters, and steam fitters; floor layers and finishers; glaziers; and roofers. The risks were greater for men employed in construction for 5 yr or longer

(RR, 2.1; CI, 1.2 to 3.9) compared to 4 yr or less (RR, 1.2; CI, 0.6 to 2.7). In the metal-fabricating category, elevated risks were found among boilermakers, sheetmetal workers, riveters, fitters, and structural maintenance workers. Risks did not differ by duration of employment in these jobs. Analysis by year first employed in construction, metal fabricating, and public service found that risks were generally higher for men starting employment after 1949 (30% of the workers) than for those employed during the 1940s (70% of the workers).

Relative risks were also elevated for most occupational categories previously linked to laryngeal cancer in at least one epidemiological study (Table 3). In particular, the risk for maintenance workers was significantly elevated (RR, 2.7), while the increased risk for woodworkers/furniture makers, based on seven cases and one control (RR, 8.1), was of borderline significance. Men employed for 5 or more yr in maintenance (RR, 5.8; CI, 1.5 to 22.0) were at higher risk than those working less than 5 yr (RR, 2.0; CI, 0.7 to 5.7). The risk was greater for those employed during the 1940s (RR, 6.1; CI, 1.6 to 22.9) than for those starting work after 1949 (RR, 1.9; CI, 0.7 to 5.5).

Table 4 presents the crude and adjusted RRs for laryngeal cancer associated with potential exposure to selected chemical and physical agents, based on data available on 180 cases and 250 controls. Exposure data for 3 cases included in the earlier analyses were not available. Nonsignificantly elevated risks were associated with exposure to chromium (RR, 1.4), wood dust (RR, 1.5), and the category of glue, lacquer, varnish, and dyes (RR, 1.4). Significantly elevated risks were seen for men with potential exposures to diesel/gasoline fumes and vapors (RR, 1.5) and to paint (RR, 1.8). The risk associated with asbestos exposure was also elevated (RR, 1.5), but of borderline significance.

In order to examine induction and latent period effects, Table 5 presents risks associated with exposure to paint, diesel/gasoline fumes, and asbestos by period of exposure. No clear patterns of risk were evident by either duration or time period, although the number of subjects exposed after 1949 was small. When subjects were classified according to their highest level of diesel/gasoline exposure (*e.g.*, low *versus* high), there was no effect of intensity. However, there was a significant trend ( $P = 0.024$ ) when subjects were categorized according to their highest level of asbestos exposure. RRs were 1.2 (CI, 0.7 to 2.1), 1.5 (CI, 0.9 to 2.5), and 2.8 (CI, 1.0 to 7.9) for low, medium, and high intensity, respectively.

## DISCUSSION

As part of an investigation into the high rates of respiratory cancer in an industrialized area of the Texas Gulf Coast, our case-control study provides information on a large series of histologically confirmed incident cases of squamous cell carcinoma

## OCCUPATION AND LARYNGEAL CANCER IN TEXAS

Table 2 *RR of laryngeal cancer associated with ever employed in broad industry and occupation categories*

Industry	SIC <sup>a</sup>	No. of cases	No. of controls	Crude RR <sup>b</sup>	Adjusted RR <sup>c</sup>	95% CI <sup>c</sup>
Agriculture	01-07	24	42	0.75	0.92	0.52-1.62
Construction	15-17	62	62	1.55	1.45	0.93-2.24
Manufacturing	20-27, 30-32, 38, 39	37	44	1.19	1.05	0.63-1.75
Metal manufacturing	33, 34	24	24	1.42	1.34	0.71-2.50
National security	97	88	133	0.81	0.72	0.48-1.08
Oil/gas extraction	13	18	31	0.77	0.88	0.46-1.67
Personal service	70-79	38	57	0.89	0.96	0.59-1.56
Petroleum refining/chemical manufacturing	28, 29	47	70	0.89	0.93	0.59-1.46
Professional/government services	60, 67, 80-96	48	78	0.78	0.82	0.53-1.28
Shipbuilding/repairing	373	23	30	1.05	1.03	0.56-1.89
Transportation, communications, utilities and sanitary services	40-49	63	58	1.74	1.62	1.04-2.51
Wholesale/retail trade	50-59	77	100	1.09	1.11	0.74-1.67
<b>Occupation</b>						
<i>DOT</i>						
Agricultural, fishery, forestry	40-45	27	51	0.68	0.77	0.45-1.31
Clerical/sales	20-29	70	99	0.94	0.99	0.66-1.49
Construction	86	51	48	1.63	1.70	1.06-2.72
Mechanic/machine repair	62, 63	34	46	1.01	1.08	0.65-1.81
Metal fabricating	80, 89	34	24	2.15	2.11	1.17-3.78
Professional, technical, management	00-19	87	131	0.82	0.91	0.61-1.36
Service occupations	30-38	69	101	0.89	0.83	0.55-1.25
Transportation	91	39	42	1.34	1.42	0.86-2.36

<sup>a</sup> Category codes for Standard Industrial Classification Manual (17) and Dictionary of Occupational Titles (18).<sup>b</sup> All risks relative to risk for those never employed in that industry or occupation.<sup>c</sup> Adjusted for smoking and drinking in a logistic model.Table 3 *RR of laryngeal cancer associated with ever employed in specific occupational categories*

Other job titles designated as high risk but without sufficient numbers were: asbestos/insulation worker; asphalt worker; barber; cement worker/mason; metal grinder/polisher; metal plater; molder/coremaker; paper worker; sheetmetal worker.

Job title	DOT <sup>a</sup>	No. of cases	No. of controls	Crude RR <sup>b</sup>	Adjusted RR <sup>c</sup>	95% CI <sup>c</sup>
Bartender	312	4	4	1.37	1.42	0.33-6.06
Boilermaker	805	5	1	6.99	7.42	0.82-66.93
Carpenter	860	19	15	1.82	1.67	0.80-3.47
Driver	292, 359, 919	15	12	1.77	1.69	0.75-3.83
Excavator	850, 859, 931	6	6	1.38	1.22	0.37-4.03
Farmer	400-407, 410, 411, 421	23	45	0.65	0.79	0.45-1.39
Machinist	600, 601	5	13	0.51	0.53	0.18-1.58
Maintenance	829, 891, 899	21	11	2.82	2.70	1.23-5.92
Mechanic	620, 638	33	46	0.98	1.06	0.63-1.77
Painter	741, 840, 845, 970	11	7	2.22	2.30	0.84-6.31
Plumber/pipefitter	862	15	14	1.51	1.90	0.86-4.19
Welders/cutters	81	18	18	1.21	1.46	0.71-3.01
Woodworker/furniture maker	665, 762, 763, 769	7	1	9.90	8.07	0.95-68.78

<sup>a</sup> Category codes from Dictionary of Occupational Titles (18).<sup>b</sup> All risks relative to risk for those never employed in that occupation.<sup>c</sup> Adjusted for smoking and drinking in a logistic model.Table 4 *RR of laryngeal cancer associated with potential occupational exposures*

Exposure	Exposed <sup>a</sup>		Crude RR <sup>b</sup>	Adjusted RR <sup>c</sup>	95% CI <sup>c</sup>
	No. of cases	No. of controls			
Arsenic	28	41	0.94	1.15	0.67-2.00
Asbestos	88	99	1.46	1.46	0.98-2.18
Chromium	62	66	1.46	1.44	0.93-2.23
Diesel/gasoline fumes	79	85	1.52	1.50	1.00-2.26
Foundry fumes	3	2	2.10	2.06	0.32-13.40
Glue, laquer/varnish, dye	34	31	1.65	1.40	0.81-2.44
Oil/grease	119	165	1.00	1.03	0.67-1.57
Paint	32	25	1.95	1.79	1.00-3.22
Sulfuric acid	22	42	0.69	0.76	0.42-1.35
Textile dust	3	5	0.83	1.28	0.29-5.60
Vinyl chloride	4	4	1.40	1.70	0.40-7.29
Wood dust	33	28	1.78	1.51	0.86-2.67

<sup>a</sup> Excludes 3 cases with unknown exposures.<sup>b</sup> For each specific exposure category risks are relative to those without that specific exposure.<sup>c</sup> Adjusted for smoking and drinking in a logistic model.

noma of the larynx. In this study we have attempted to clarify the role of occupational exposures while taking account of potential confounding by the major risk factors, cigarette smoking and alcohol consumption.

While 28% of our control series were selected from death certificates and therefore are not representative of the general

population, they are representative of deceased persons from the 6-county area. Occupational risk factors were not found to differ by vital status, so that adjustment for this variable was not necessary. This is consistent with other studies (29, 30) which have found that close relatives of white males are able to report work histories fairly accurately, except for jobs held 1 yr or less (31).

Occupational exposures based on employer, job title, and duties were analyzed using various categories of occupations and industries and potential chemical and physical exposures as determined by an industrial hygienist. Although each agent may have been found in a variety of occupations and industries, and many occupations and industries were associated with more than one exposure, the results of each analysis are discussed separately.

Analysis of industrial and occupational categories revealed significantly elevated risks for those ever employed in the public services industry and in the occupations of metal fabricating, maintenance, and construction. In the public services industry, excess risks were observed for those working in water transportation, particularly marine cargo handlers. We could not implicate specific exposures in this industry, since a wide variety of materials are shipped, including grains, petroleum products,

Table 5 RR of laryngeal cancer by duration and time period of exposure to selected agents

	Time period <sup>a</sup>	No. of yr exposed			Unknown	Total	95% CI
		<5	5-14	≥ 15			
Paint <sup>b</sup>	<1950	1.1 (7, 11) <sup>c</sup>	5.0 (9, 2)	1.6 (7, 5)	0 (0, 1)	1.6	0.8-3.2
	1950-59	2.0 (2, 2)	0 (0, 0)	0 (0, 1)	(1, 0)	3.3	0.6-18.9
	>1959	∞ (4, 0)	0.5 (1, 3)	0 (0, 1)	(0, 0)	1.9	0.5-7.4
	Total	1.7	2.3	1.6			
	95% CI	0.7-3.8	0.7-7.4	0.5-4.8			
Diesel/gasoline fumes <sup>d</sup>	<1950	1.6 (25, 27)	1.9 (15, 11)	1.8 (24, 22)	(2, 6)	1.6	1.0-2.5
	1950-59	3.9 (6, 3)	0.6 (1, 4)	1.3 (2, 2)	(2, 2)	2.0	0.8-4.8
	>1959	1.0 (1, 2)	0 (0, 3)	0 (0, 2)	(1, 1)	0.3	0.1-1.6
	Total	1.8	1.3	1.6			
	95% CI	1.0-3.1	0.6-2.7	0.8-2.9			
Asbestos <sup>e</sup>	<1950	1.5 (16, 18)	1.9 (17, 14)	1.2 (34, 45)	(2, 9)	1.3	0.8-2.0
	1950-59	1.7 (3, 3)	5.7 (3, 1)	∞ (5, 0)	(1, 1)	4.9	1.6-14.7
	>1959	0.3 (1, 5)	2.5 (4, 3)	∞ (1, 0)	(1, 0)	1.5	0.5-4.4
	Total	1.3	2.2	1.4			
	95% CI	0.7-2.6	1.1-4.3	0.8-2.4			

<sup>a</sup> Adjusted for smoking and drinking in a logistic model.<sup>b</sup> Referent group is 148 cases, 225 controls without paint exposure.<sup>c</sup> Numbers in parentheses, numbers of cases and controls.<sup>d</sup> Referent group is 101 cases, 165 controls without diesel/gas exposure.<sup>e</sup> Referent group is 92 cases, 151 controls without asbestos exposure.

and chemicals. An excess risk of laryngeal cancer has been reported among men working at harbors in a case-control study in Denmark (8) and among dockyard workers in Italy (32).

An increased risk of laryngeal cancer among workers in metal industries has been previously reported (19, 22, 33). Although we found only a slight excess risk for industries involved in metal manufacturing, the risk associated with metal-fabricating occupations was significantly elevated. The latter category included jobs both in metal fabricating (riveters, fitters, tin and copper smiths, sheetmetal workers, boilermakers, transportation assemblers, and body workers) and in structural work and structural maintenance. Previous studies have also reported elevated risks of laryngeal cancer among sheetmetal workers and maintenance personnel (1, 2).

Construction workers had a significantly elevated risk of laryngeal cancer, as reported by others (1, 33). Within this category the risks were elevated among plumbers/pipefitters and carpenters, which is also consistent with other surveys (6). These workers may be exposed to recognized or suspected respiratory carcinogens including asbestos, various solvents, wood dust, and formaldehyde.

Analysis of chemical and physical exposures revealed significantly elevated risks associated with potential exposures to paint and to diesel/gasoline fumes and vapors. In addition, nonsignificant increases in risk (RR, 1.4 or greater) were observed following exposures to asbestos, chromium, wood dust, and the category of glues, lacquers, varnishes, and dyes.

The risk associated with paint exposure (RR, 1.8) may be related in part to the risk following chromium exposure (RR, 1.4). Chromium, a pulmonary carcinogen in humans (34), is one of the major pigments used in paint. Chromium exposures occur during spray painting, which has been linked to respiratory cancer in one study (35) although not in another (36). The link to chromium, however, is tenuous in our study of 128 exposed workers. The relative risk for the 53 workers with potential exposure to both chromium and paint was 1.7, but the risk was only 1.2 for the 75 workers exposed to chromium alone. Although an evaluation of risk by duration of exposure to paint detected no evidence of dose response, our findings are compatible with surveys of painters, indicating an excess risk of respiratory cancers including the lung (35, 37, 38) and the

larynx (21, 33). The risk for painters in our study was elevated, but not significantly.

Workers exposed to diesel/gasoline vapors and fumes had a significantly increased risk (RR, 1.5), although no dose-response gradient was seen when analyzed by duration of exposure. A similar but nonsignificant risk was seen for drivers. An excess risk of laryngeal cancer has previously been reported among workers exposed to vehicle fumes (6) and among professional drivers (2, 5, 8). Similar associations have been observed for lung cancer (39-41).

Asbestos exposure has been linked to laryngeal cancer in several studies (1, 3, 4, 6, 8), although the finding is not consistent (19, 42). In our study, asbestos exposure was associated with a nonsignificant increase in risk (RR, 1.5). Although there was no clear dose response when analyzed by duration of exposure, a positive gradient was found when asbestos was categorized by intensity of exposure. Risks were also elevated for occupational groups with potential exposure to asbestos, i.e., boilermakers, sheetmetal workers, plumbers/pipefitters, and carpenters.

Wood dust exposure was also related to laryngeal cancer (RR, 1.5), but most of these workers (including carpenters and woodworkers) also had exposure to glues, lacquers, varnishes, and dyes (RR, 1.4). Wood dust exposure has been clearly related to sinonasal cancers (43, 44), and excess risks for cancers of the larynx (5, 45) and lung (46) have been suggested as well. In a recent study of respiratory cancer in the wood industry, the elevated risks appeared related to pesticide and phenol exposures (47).

An increased risk of laryngeal cancer has been found in a group of workers heavily exposed to sulfuric acid at a large refinery and chemical plant in Louisiana (7). In contrast, we found reduced risks among workers in petroleum and chemical manufacturing industries (RR, 0.9) or with potential exposure to sulfuric acid (RR, 0.8).

The case-control method is limited in the degree of specificity that can be collected on occupational exposures. Beyond our control is the difficulty in recalling information by self-respondents and often the lack of knowledge by their next-of-kin. There is also the potential for misclassification of chemical exposures. The type and level of exposures may vary greatly among those having a particular job title due to differences in the work

processes, control systems, and protective measures. Furthermore, the occupational histories in our study were restricted to employment after 1939. While this afforded an opportunity to ascertain adult jobs for nearly all of the subjects, information was not obtained on very early exposures, and the year of first employment could not be assessed for those aged 70 to 79. As in all studies involving multiple statistical comparisons, one must be circumspect in interpreting results, since some significant associations are expected to occur by chance alone. Further caution is needed when cases and controls are not representative of their respective populations, since not all of the area hospitals or eligible subjects participated in our study.

Despite its limitations, our study was able to detect elevated risks for laryngeal cancer associated with certain jobs and exposures that could not be explained by differential patterns of cigarette smoking, alcohol consumption, or diet. Further research is needed to clarify the occupational determinants of laryngeal cancer, thus enlarging our understanding of the origins of this tumor, and enabling more effective preventive measures.

## ACKNOWLEDGMENTS

The authors wish to thank Charles Contant and Dr. Irene Easling of the University of Texas Health Science Center School of Public Health at Houston for their contributions in the conduct of the study; Dianna Jessee for secretarial support; and Dr. Kenneth Rothman, Professor of Family and Community Medicine, University of Massachusetts Medical School, for his critical review and constructive suggestions.

## REFERENCES

- Flanders, W. D., and Rothman, K. J. Occupational risk for laryngeal cancer. *Am. J. Public Health*, 72: 369-372, 1982.
- Flanders, W. D., Cann, C. I., Rothman, K. J., and Fried, M. P. Work-related risk factors for laryngeal cancer. *Am. J. Epidemiol.*, 119: 23-32, 1984.
- Morgan, R. W., and Shettigara, P. T. Occupational asbestos exposure, smoking, and laryngeal carcinoma. *Ann. NY Acad. Sci.*, 271: 308-310, 1976.
- Hinds, M. W., Thomas, D. B., and O'Reilly, H. P. Asbestos, dental X-rays, tobacco, and alcohol in the epidemiology of laryngeal cancer. *Cancer (Phila.)*, 44: 1114-1120, 1979.
- Wynder, E. L., Covey, L. S., Mabuchi, K., and Mushinski, M. Environmental factors in cancer of the larynx. A second look. *Cancer (Phila.)*, 38: 1591-1601, 1976.
- Burch, J. D., Howe, G. R., Miller, A. B., and Semenciw, R. Tobacco, alcohol, asbestos, and nickel in the etiology of cancer of the larynx: a case-control study. *J. Natl. Cancer Inst.*, 67: 1219-1224, 1981.
- Soskolne, C. L., Zeighami, E. A., Hanis, N. M., Kupper, L. L., Herrmann, N., Amsel, J., Mausner, J. S., and Stellman, J. M. Laryngeal cancer and occupational exposure to sulfuric acid. *Am. J. Epidemiol.*, 120: 358-369, 1984.
- Olsen, J., and Sabroe, S. Occupational causes of laryngeal cancer. *J. Epidemiol. Commun. Health*, 38: 117-121, 1984.
- McMichael, A. J. Increases in laryngeal cancer in Britain and Australia in relation to alcohol and tobacco consumption trends. *Lancet*, 1: 1244-1247, 1978.
- Tuyns, A. J. Epidemiology of alcohol and cancer. *Cancer Res.*, 39: 2840-2843, 1979.
- Rothman, K. J., Cann, C. I., Flanders, D., and Fried, M. P. Epidemiology of laryngeal cancer. *Epidemiol. Rev.*, 2: 195-209, 1980.
- Flanders, W. D., and Rothman, K. J. Interaction of alcohol and tobacco in laryngeal cancer. *Am. J. Epidemiol.*, 115: 371-379, 1982.
- Graham, S., Mettlin, C., Marshall, J., Priore, T. R., and Shedd, D. Dietary factors in the epidemiology of cancer of the larynx. *Am. J. Epidemiol.*, 113: 675-680, 1981.
- Mason, T. J., McKay, F. W., Hoover, R., Blot, W. J., and Fraumeni, J. F., Jr. Atlas of Cancer Mortality for US Counties: 1950-69, DHEW Publication No. (NIH) 75-780. Washington, DC: US Government Printing Office, 1975.
- Blot, W. J., and Fraumeni, J. F., Jr. Studies of respiratory cancer in high risk communities. *J. Occup. Med.*, 21: 276-278, 1979.
- US Department of Agriculture. Foods Commonly Eaten by Individuals: Amount per Day and per Eating Occasion, Home Economics Research Report No. 44. Hyattsville, MD: US Government Printing Office, 1982.
- Office of Management and Budget. Standard Industrial Classification Manual. Washington, DC: US Government Printing Office, 1972.
- US Department of Labor. Dictionary of Occupational Titles, Ed. 4. Washington, DC: US Government Printing Office, 1977.
- Zagraniski, R. T., Kelsey, J. L., and Walter, S. D. Occupational risk factors for laryngeal carcinoma: Connecticut, 1975-1980. *Am. J. Epidemiol.*, 124: 67-76, 1986.
- Olsen, J., Sabroe, S., and Lager, M. Welding and cancer of the larynx: a case-control study. *Eur. J. Cancer Clin. Oncol.*, 20: 639-643, 1984.
- Englund, A. Cancer incidence among painters and some allied trades. *J. Toxicol. Environ. Health*, 6: 1267-1273, 1980.
- Williams, R. R., Stegens, N. L., and Goldsmith, J. R. Associations of cancer site and type with occupation and industry from Third National Cancer Survey interview. *J. Natl. Cancer Inst.*, 59: 1147-1185, 1977.
- Cowles, S. R. Cancer of the larynx: occupational and environmental associations. *South. Med. J.*, 76: 894-898, 1983.
- Fleiss, J. L. Statistical Methods for Rates and Proportions, pp. 26-27. New York: Wiley, 1981.
- Gart, J. J. The comparison of proportions: review of significance tests, confidence intervals, and adjustments for stratification. *Rev. Int. Stat. Inst.*, 39: 148-169, 1971.
- Cox, D. R. The Analysis of Binary Data, pp. 14-19. London: Methuen, 1970.
- Dixon, W. J. (ed.). BMDP Statistical Software 1983, pp. 330-342. Berkeley, CA: University of California Press, 1983.
- Mantel, N. Chi-square tests with one degree of freedom, extensions of Mantel-Haenszel procedure. *J. Am. Stat. Assoc.*, 58: 690-700, 1963.
- Pickle, L. W., Brown, L. M., and Blot, W. J. Information available from surrogate respondents in case-control interview studies. *Am. J. Epidemiol.*, 118: 99-108, 1983.
- McLaughlin, J. K., Blot, W. J., Mehl, E. S., and Mandel, J. S. Problems in the use of dead controls in case-control studies. I. General results. *Am. J. Epidemiol.*, 127: 131-139, 1985.
- Lerchen, M. I., and Samet, J. M. An assessment of the validity of questionnaire responses provided by a surviving spouse. *Am. J. Epidemiol.*, 123: 481-489, 1986.
- Bonassi, S., Ceppi, M., Putoni, R., Valeria, F., Vercelli, M., Belli, S., Biocca, M., Comba, P., Ticchiarelli, L., Mariotti, F., Taddeo, D., Zuccherelli, D., Casalini, A., Perini, C., Nelli, L., Sansoni, G., Pupp, N., Farina, M., and Luciani, A. Mortality studies of dockyard workers (longshoremen) in Italy. *Am. J. Ind. Med.*, 7: 219-227, 1985.
- Coggon, D., Pannett, B., Osmond, C., and Acheson, E. D. A survey of cancer and occupation in young and middle aged men. I. Cancers of the respiratory tract. *Br. J. Cancer*, 43: 332-338, 1986.
- Hayes, R. B. Carcinogenic effects of chromium. *Top. Environ. Health*, 5: 221-247, 1982.
- Dalager, N. A., Mason, T. J., Fraumeni, J. F., Jr., Hoover, R., and Payne, W. W. Cancer mortality among workers exposed to zinc chromate paints. *J. Occup. Med.*, 22: 25-29, 1980.
- Chiazze, L., Jr., Ference, L. D., and Wolf, P. H. Mortality among automobile assembly workers. I. Spray painters. *J. Occup. Med.*, 22: 520-526, 1980.
- Stockwell, H. G., and Matanoski, G. M. A case-control study of lung cancer in painters. *J. Occup. Med.*, 27: 125-126, 1985.
- Matanoski, G. M., Stockwell, H. G., Diamond, E. L., Sweeney, M. H., Joffe, R. D., Mele, L. M., and Johnson, M. L. A cohort mortality study of painters and allied tradesman. *Scand. J. Work Environ. Health*, 12: 16-21, 1986.
- Howe, G. R., Fraser, D., Lindsey, J., Presnal, B., and Yu, S. Z. Cancer mortality (1965-77) in relation to diesel fume and coal exposure in a cohort of retired railway workers. *J. Natl. Cancer Inst.*, 70: 1015-1019, 1983.
- Schenker, M. B., Smith, T., Munoz, A., Woskie, S., and Speizer, F. E. Diesel exposure and mortality among railway workers: results of a pilot study. *Br. J. Ind. Med.*, 41: 320-327, 1984.
- Damber, L., and Larsson, L. G. Professional driving, smoking, and lung cancer: a case referent study. *Br. J. Ind. Med.*, 42: 246-252, 1985.
- Blot, W. J., Morris, L. E., Stroube, R., Tagnon, I., and Fraumeni, J. F., Jr. Lung and laryngeal cancers in relation to shipyard employment in coastal Virginia. *J. Natl. Cancer Inst.*, 65: 571-575, 1980.
- Brinton, L. A., Blot, W. J., Stone, B. J., and Fraumeni, J. F., Jr. A death certificate analysis of nasal cancer among furniture workers in North Carolina. *Cancer Res.*, 37: 3473-3474, 1977.
- Brinton, L. A., Blot, W. J., Becker, J. A., Winn, D. M., Browder, J. P., Farmer, J. C., and Fraumeni, J. F., Jr. A case-control study of cancers of the nasal cavity and paranasal sinuses. *Am. J. Epidemiol.*, 119: 896-906, 1984.
- Wolf, O. V. Occupational and non-occupational factors involved in laryngeal cancer. *Z. Ges. Hyg. Grenz.*, 24: 174-177, 1978.
- Blot, W. J., Davies, J. E., Brown, L. M., Nordwall, C. W., Buiatti, E., Ng, A., and Fraumeni, J. F., Jr. Occupation and the high risk of lung cancer in northeast Florida. *Cancer (Phila.)*, 50: 364-371, 1982.
- Kauppinen, T. P., Partanen, T. J., Nurminen, M. M., Nickels, J. I., Hernberg, S. G., Hakulinen, T. R., Pukkala, E. I., and Savonen, E. T. Respiratory cancers and chemical exposures in the wood industry: a nested case-control study. *Br. J. Ind. Med.*, 43: 84-90, 1986.